

# NEC



## NATIONAL ELECTRICAL CODE

BY AHMED ABD EL MEGEED ISMAIL  
AT WWW.SAYEDSAAD.COM

# LEC#8

## MOTORS PART2

EXAMPLE -M04 ( مثال تطبيقي )

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APPLICATION AND SELECTION (OCPD) FOR MULTI-MOTOR COMPRESSOR + MOTORS (حساب القاطع لمجموعة كباسات تكييف ومجموعة أخرى من المواتير)

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COMBINATION LOAD (MOTORS, MOTOR COMPRESSORS , OTHER LOADS ) (حساب الكابل لمجموعة كباسات تكييف ومجموعة أخرى من المواتير ومجموعة أخرى من الأحمال)

RATING AND INTERRUPTING CAPACITY (DISCONNECTING SWITCH FOR SINGLE MOTOR COMPRESSOR (حساب مفتاح الفصل لكباس تكييف واحد)

RATING (DISCONNECTING SWITCH FOR MULTI MOTOR COMPRESSORS + OTHER MOTORS ) (حساب مفتاح الفصل لمجموعة كباسات تكييف ومجموعة أخرى من المواتير ومجموعة أخرى من الأحمال)

EXAMPLE -MC1 ( مثال تطبيقي )

EXAMPLE -MC2 ( مثال تطبيقي )

EXAMPLE -MC3 ( مثال تطبيقي )

# **LEC#8**

## **MOTORS PART2**

EXA -M04

EXA -M05

### **SERVICE FACTOR**

430.32(A)(1) MINIMUM SIZE OVERLOAD PROTECTION

430.32(C) MAXIMUM SIZE OVERLOAD PROTECTION

EXA -OV1

### **MOTOR-COMPRESSOR.**

440.22 (A) APPLICATION AND SELECTION (OCPD) FOR SINGLE MOTOR COMPRESSOR

440.22 (B)(1) APPLICATION AND SELECTION (OCPD) FOR MULTI-MOTOR COMPRESSOR + MOTORS

440.32 SINGLE MOTOR-COMPRESSOR CONDUCTOR

440.33 CONDUCTOR OF MOTOR-COMPRESSOR(S) + MOTORS

440.34 COMBINATION LOAD (MOTORS, MOTOR COMPRESSORS, OTHER LOADS)

440.12 (A)(1) RATING AND INTERRUPTING CAPACITY (DISCONNECTING SWITCH) FOR SINGLE MOTOR COMPRESSOR

440.12 (B)(2) RATING (DISCONNECTING SWITCH) FOR MULTI MOTOR COMPRESSORS + OTHER MOTORS

EXA -MC1

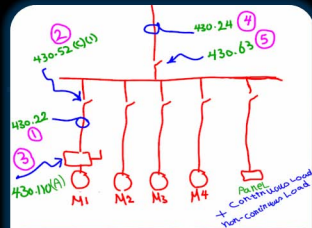
EXA -MC2

EXA -MC3

# EXA - M04

لوحة بها اربعة مواثر احمالهم كالاتي ولوحة فرعية بها مجموعة احمال non continuous وcontinuous بحسب الكابلات والقواطع ومفتاح الفصل الممثلين في الارقام من 1 الى 5 في الشكل التالي

M1=30 KVA = 46 A  
 M2= 20 KVA =30 A  
 M3=25 KVA =38A  
 M4=25KVA =38 A  
 Continuous load 10 KVA= 15.2 A  
 Non continuous load 15 KVA= 23 A



$M_1 = 30 \text{ kVA}$   
 $M_2 = 20 \text{ kVA}$   
 $M_3 = 25 \text{ kVA}$   
 $M_4 = 25 \text{ kVA}$

3PH  
 380V

contin down load = 10kVA  
 non-contin down load = 15kVA

(1) CABLE  $430.22 = 46 \times 1.25 =$

$= 57.5A = 10 \text{ MM}^2$

(2) CIRCUIT BREAKER (inverse time)

$430.52(C)(1) \text{ table } 430.52 = 46 \times 2.5 = 115 A = 125 A$

(3) DISCONNECTING SWITCH = all  $430.110 (A)$

$= \text{all loads} \times 1.15 = 46 \times 1.15 = 53 A = 60 A$

(4) CABLE  $430.24 = \text{largest motor ampere} \times 1.25 + \text{full load ampere of other motors} \times 1 + \text{continuous loads (non motors)} \times 1.25 + \text{non continuous loads (non motors)} \times 1$

$= 46 \times 1.25 + 30 + 38 + 38 + 15.2 \times 1.25 + 23 \times 1 = 205 A$

$70 \text{ MM}^2$

(5) CIRCUIT BREAKER (inverse time)  $430.63 = \text{largest motor ampere} \times 2.5 + \text{full load ampere of other motors} \times 1 + \text{other loads} \times 1$

$= 46 \times 2.5 + 30 + 38 + 38 + 15.2 + 23 = 259 A = 320 A$

## EXA - M04

|                               |     |     |       |     |
|-------------------------------|-----|-----|-------|-----|
| Cable selection current (Amp) |     |     | 205.0 |     |
| C.B selection current(Amp)    |     |     | 259.0 |     |
| Circuit breaker size          | 320 | AT  | 400   | AF  |
| Cable size                    | 70  | mm2 | 220   | Amp |
| No. of parallel cables /ph    | 1   |     | 220   | Amp |

## EXA - M05

البك نفس المثال بال **1.25 RULE** للنقاط 4 و 5

$$\text{CABLE} = \text{all loads} \times 1.25$$

$$= 125 \times 1.25 \text{KVA} = 156.25 \text{KVA} = \mathbf{95 \text{ MM}^2}$$

$$\text{CIRCUIT BREAKER} = (\text{all loads} \times 1.25)$$

$$= 125 \times 1.25 \text{KVA} = 156.25 \text{ KVA} = \mathbf{250 \text{ A}}$$

لا حظ ان الكابل ذاد 95 عن المثال السابق وانه ليس مبرر ان يقل  
القاطع العمومي الى 250 لمراعاة ال starting

|                                     |        |     |                               |        |
|-------------------------------------|--------|-----|-------------------------------|--------|
| Design load                         | 156.25 |     | Conductor type                | Copper |
| Total Correction factor             |        |     | KT                            | 1      |
| CABLE AND CIRCUIT BREAKER SELECTION |        |     |                               |        |
| Current after derating (Amp)        | 237.7  |     | Cable selection current (Amp) | 237.7  |
| C.B selection current(Amp)          |        |     | 237.7                         |        |
| Circuit breaker size                | 250    | AT  | 250                           | AF     |
| Cable size                          | 95     | mm2 | 272                           | Amp    |
| No. of parallel cables /ph          | 1      |     | 272                           | Amp    |

# SERVICE FACTOR

## Service Factor

Sizing motor **overload** protection depends on the service factor of the motor. The service factor is found on the motor nameplate.

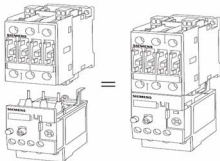
Simply stated, a motor may be loaded continuously up to the horsepower obtained by multiplying

the rated horsepower by the service factor. For example, a **10-horsepower** motor marked with a **service factor of 1.15** may be loaded to **11.5** horsepower. Consider service factor a margin of safety.

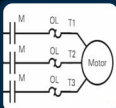
هو معامل من خلاله يتم تحديد مقياس الـ over load وهو المعامل الموجود على ألـ name plate للموتور وهو يعبر عن النسبة الزائدة التي يمكن للموتور تحمليه بها عل سبيل المثال إذا كان الموتور حملة 10 KW وكان الـ Service Factor 1.15 هذا يعني ان هذا الموتور يمكن تحمليه بـ 11.5 KW

Contactor

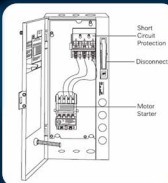
Starter



Overload Relay



## OVER LOAD + CONTACTOR = MOTOR STARTER



العاطع والـ over load في لوحة واحدة وأيضاً ألـ contactor  
ألـ starter

## 430.32(A)(1) MINIMUM SIZE OVERLOAD PROTECTION

- Motors, with a marked service factor not less than 1.15, use 125 percent
- Motors, with a marked temperature rise not over 40°C, use 125 percent
- All other motors - 115% x FLA

## 430.32(C) MAXIMUM SIZE OVERLOAD PROTECTION

- Motors, with marked service factor not less than 1.15, use 140% x FLA
- Motors, with a marked temperature rise not over 40°C, use 140% x FLA
- All other motors - 130% x FLA

من ال (1) section 430.32 (A) و (C) 430.32 تجد ان  
افضل ال factors هو 140% وهذا لان طبيعة التصميم ان  
معلوماتنا عن المواثير المستخدمة في المشروع تكاد تكون  
بسيطة جدا لذا اختارنا اعلى معامل

## EXA-OV1

- مونور 25 KVA ما هو ال over load المناسب له ؟؟؟؟
- full load ampere =  $25 \times 1000 / 1.73 / 380 = 38 \text{ A}$
- =====> from manufacturer's chart base o 38 A

## MOTOR-COMPRESSOR.

هو جمع ما بين مونور وكباس يعتبر مبرد يستخدم في التبريد  
واحيرا هوا يسمى **كباس**

## 440.22 (A) APPLICATION AND SELECTION (OCPD) FOR SINGLE MOTOR COMPRESSOR

### (A) Rating or Setting for Individual Motor-Compressor.

The **motor-compressor** branch-circuit short-circuit and ground-fault protective device shall be capable of carrying the starting current of the motor. A protective device having a rating or setting not **exceeding 175** percent of the motor-compressor rated-load current or branch-circuit selection current, whichever is greater, shall be permitted, provided that, where the protection specified is not sufficient for the starting current of the motor, the rating or setting shall be permitted to be increased but shall not **exceed 225** percent of the motor rated-load current or branch-circuit selection current, whichever is greater.

- يتم حساب سعة القاطع الخاص بالمونور كومبريسور واحد من 175 % الى 225% من ال Rated Ampere

## CIRCUIT BREAKER ONE MOTOR

**COMPRESSOR** =  $440.22(A) =$

**FULL LOAD AMPERE X (1.75 OR 2.25)**

يستخدم ال 225% حالة ان يكون القاطع غير كافى لبدء المونور  
كومبريسور انظر الشكل MO الصفحة التالية

## 440.22 (B)(1) APPLICATION AND SELECTION (OCPD) FOR MULTI-MOTOR COMPRESSOR + MOTORS (EXA. CHILLER)

(1) Motor-Compressor Largest Load Where a **hermetic refrigerant motor-compressor** is the largest load connected to the circuit, the rating or setting of the branch-circuit short-circuit and ground-fault protective device shall not exceed the value specified in **440.22(A)** for the **largest motor-compressor plus** the **sum** of the **rated-load current** or branch-circuit selection current, whichever is greater, of the other motor-compressor(s) and the ratings of the other loads supplied.

## CIRCUIT BREAKER MORE THAN ONE

**MOTOR COMPRESSOR = IF MOTOR COM .IS**

**LARGEST LOAD IN THE GROUP =  $440.22(A) +$  full**

**load ampere of other motor compressors**

**=  $225\% \times$  FULL LOAD AMPERE OF LARGEST MOTOR**

**COMPRESSOR + FULL LOAD AMPERE OF OTHER MOTOR COMPRESSORS**

انظر الشكل MO الصفحة التالية

## 440.32 SINGLE MOTOR-COMPRESSOR CONDUCTOR.

Branch-circuit conductors supplying a single motor-compressor shall have an ampacity not less than 125 percent of either the motor-compressor rated-load current or the branch-circuit selection current, whichever is greater.

**CABLE OF ONE MOTOR COMPRESSOR = 440.32**  
= FULL LOAD AMPERE X (1.25)

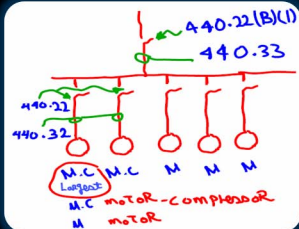
انظر الشكل MO التالي

## 440.33 CONDUCTOR OF MOTOR-COMPRESSOR(S) + MOTORS

Conductors supplying one or more motor-compressor(s) with or without an additional load(s) shall have an ampacity not less than the sum of the rated-load or branch-circuit selection current ratings, whichever is larger, of all the motor-compressors plus the full-load currents of the other motors, plus 25 percent of the highest motor or motor-compressor rating in the group.

**CABLE OF MORE THAN ONE MOTOR COMPRESSOR+ MOTORS = IF MOTOR COM IS LARGEST LOAD IN THE GROUP = 440.32+ full load ampere of other motor compressors, motors = 125% X FULL LOAD AMPERE OF LARGEST MOTOR COMPRESSOR+ FULL LOAD AMPERE OF OTHER MOTOR COMPRESSORS, MOTORS**

انظر الشكل MO التالي



شکل MO

## 440.34 COMBINATION LOAD (MOTORS, MOTOR COMPRESSORS, OTHER LOADS)

Conductors supplying a motor-compressor load in addition to other load(s) as calculated from Article 220 and other applicable articles shall have an ampacity sufficient for the other load(s) plus the required ampacity for the motor-compressor load determined in accordance with 440.33 or, for a single motor-compressor, in accordance with 440.32.



**CABLE OF MORE THAN ONE MOTOR COMPRESSOR+ MOTORS = IF MOTOR COM .IS LARGEST LOAD IN THE GROUP=**  $440.33 + \text{full load ampere of other motor compressors, motors} + 1.25 \times \text{cont. loads} + 1 \times \text{no cont. loads}$   
**=125% X FULL LOAD AMPERE OF LARGEST MOTOR COMPRESSOR+ FULL LOAD AMPERE OF OTHER MOTOR COMPRESSORS, MOTORS+ 1.25 X CONT. LOADS+ 1 X NO CONT. LOADS**

انظر الشكل MO1 التالي

الكامل المفدى للوحة بها مواشير واحمال عادية و motor compressors اخرى يحسب مفاصة كالآتي

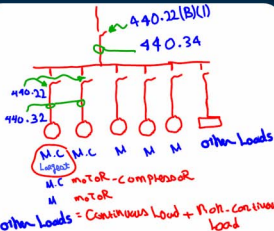
125% x اكبر موتور كومبريسور

100% x لباقي المواشير + باقى موتور كومبريسور

100% للاحمال ال non continuous لتغير المواشير عل سبيل المثال برابز وغير ذلك.

125% للاحمال ال continuous لتغير المواشير عل سبيل المثال اشارة وغير ذلك.

**MOTOR CONDUCTOR** لاحظ ان **430.24** للمواشير اى **RULE** هي **440.34** للموتور كومبريسور وهي نفس ال **CONTINUITY RULE**



شكل MO1

**440.12 (A)(1) RATING AND INTERRUPTING CAPACITY (DISCONNECTING SWITCH FOR SINGLE MOTOR COMPRESSOR**

(A) Hermetic Refrigerant **Motor-Compressor**. A **disconnecting** means serving a hermetic refrigerant **motor-compressor** shall be selected on the basis of the nameplate rated-load current or branch-circuit selection current, whichever is greater, and locked-rotor current, respectively, of the motor-compressor as follows.

(1) **Ampere Rating.** The ampere rating shall be at least 115 percent of the nameplate rated-load current or branch-circuit selection current, whichever is greater.

ال **DISCONNECTED SWITCH** لموتور كومبريسور واحد يساوي 115% من ال rated ampere motor طبعاً كثير يضعونه مثل الفاطح وهذا غير صحيح على الاطلاق ومكلف والبعض يضربون في 1.25 وهذا ايضا مكلف ولا يصح الا الصحيح .

## 440.12 (B)(2) RATING (DISCONNECTING SWITCH FOR MULTI MOTOR COMPRESSORS + OTHER MOTORS

(B) **Combination Loads.** Where the combined load of two or more hermetic refrigerant motor-compressors or one or more hermetic refrigerant motor-compressor with other motors or loads may be simultaneous on a single disconnecting means, the rating for the disconnecting means shall be determined in accordance with 440.12(B)(1) and (B)(2).

(2) **Full-Load Current Equivalent.** The ampere rating of the disconnecting means shall be at least 115 percent of the sum of all currents at the rated-load condition determined in accordance with 440.12(B)(1).

عندما يكون هناك اكثر من موتور كومبريسور واحمال اخرى مثلا ال **115%** يكون مفتاح الفصل مجموع تيار احمال يضرب في

اشهر الامثلة ال **CHILLER** فهي عبارة عن مجموعة مراوح ومجموعة كباسات ولها فاطح وكابل واحد ومفتاح فصل واحد

## EXA - MC1

وحدة **CHILLER** تحتوي عل 6 مراوح للوحدة 500VA و 6 كباسات اي motor compressors حمل الواحد 15 KVA ماهو الفاطح العمومي لها وايضا الكابل العمومي ومفتاح الفصل الخاص بها

Fan ampere 500 VA =  $500 / 1.73 / 380 = 0.76$  A  
Motor compressor 15000VA =  $15000 / 1.73 / 380 = 22$  A

**(1) CIRCUIT BREAKER 440.22(B)(1) = 225% X FULL LOAD AMPERE OF LARGEST MOTOR COMPRESSOR + FULL LOAD AMPERE OF OTHER MOTOR COMPRESSORS + FULL LOAD AMPERE OF OTHER MOTORS**

=  $22 * 2.25 + 22 * 5 + 0.76 * 6 = 164A = 200A$

**(2) CABLE 440.33 = 125% X FULL LOAD AMPERE OF LARGEST MOTOR COMPRESSOR + FULL LOAD AMPERE OF OTHER MOTOR COMPRESSORS , MOTORS**

=  $22 * 1.25 + 22 * 5 + 0.76 * 6 = 142A = 35MM^2$

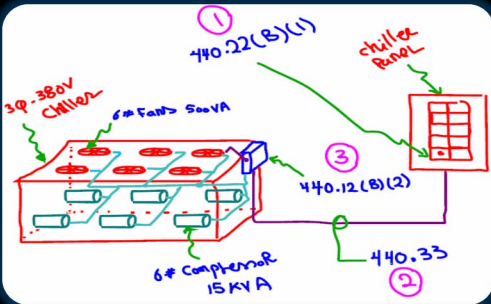
**(3) DISCONNECTING SWITCH = 440.12**

**(B)(2) = all loads x 1.15**

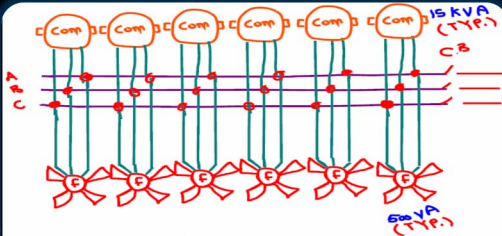
=  $(22 * 6 + 0.76 * 6) 1.15 = 157A = 160A$

EXA-MC1

|                            |     |     |                               |       |
|----------------------------|-----|-----|-------------------------------|-------|
|                            |     |     | Cable selection current (Amp) | 142.0 |
|                            |     |     | C.B selection current(Amp)    | 164.0 |
| Circuit breaker size       | 200 | AT  | 250                           | AF    |
| Cable size                 | 35  | mm2 | 142                           | Amp   |
| No. of parallel cables /ph | 1   |     | 142                           | Amp   |



EXA-MC1



Electrical wiring Diagram

Electrical wiring Diagram

## EXA-MC1

## EXA-MC2

البيك نفس المثال بال 1.25 RULE للنقاط

(1) **CIRCUIT BREAKER** = (all loads x 1.25  
 $= (15 \times 6 + 0.5 \times 6) \times 1.25 = 116.25 \text{ KVA} = 200 \text{ A}$

(2) **CABLE** = all loads x 1.25  
 $= (15 \times 6 + 0.5 \times 6) \times 1.25 = 116.25 \text{ KVA} = 70 \text{ MM}^2$

(3) **DISCONNECTING SWITCH** = all loads x 1.25  
 $= (15 \times 6 + 0.5 \times 6) \times 1.25 = 116.25 \text{ KVA} = 176 \text{ A} = 200 \text{ A}$

لا حظ ان الكابل داد 70 عن المثال السابق

|  |        |     |                               |                         |        |
|--|--------|-----|-------------------------------|-------------------------|--------|
| Design load                                | 116.25 |     |                               | Conductor type          | Copper |
|  |        |     |                               | Total Correction factor | KT 1   |
| <b>CABLE AND CIRCUIT BREAKER SELECTION</b> |        |     |                               |                         |        |
| Current after derating (Amp)               | 176.8  |     | Cable selection current (Amp) | 176.8                   |        |
| Circuit breaker size                       | 200    | AT  | C.B selection current(Amp)    | 176.8                   | 250 AF |
| Cable size                                 | 70     | mm2 | Total catalogue Ampacity      | 220                     | Amp    |
| No. of parallel cables /ph                 | 1      |     | Adjusted Ampacity             | 220                     | Amp    |
| Phase to phase voltage (kV)                | 1      |     | Selected switchgear           | SSD                     | unit   |
| Phase to ground voltage (kV)               | 1      |     | Selected switchgear           | SSD                     | unit   |

## EXA-MC2

## EXA-MC3

وحدة تكييف Central split عبارة عن الاتي

2# Outdoor compressor (CO1)= 20 KVA 3 ph ,380 V  
 Outdoor fan (M1)= 1 KVA 3 ph ,380 V  
 Indoor fan (M2)= 3 KVA 3 ph ,380 V

لاحظ ان اللوحة تغذي الوحدة الخارجية وهناك كابل من الخارجية لتغذية الداخلية بالرجاء حساب النقاط من 1 الى 4

$$CO1=20/1.73/380= 30.4 A$$

$$CO2=20/1.73/380= 30.4 A$$

$$M1=1/1.73/380= 1.5 A$$

$$M2=3/1.73/380= 4.5 A$$

**(1) CIRCUIT BREAKER 440.22(B)(1)=125% X FULL LOAD AMPERE OF LARGEST MOTOR COMPRESSOR+ FULL LOAD AMPERE OF OTHER MOTOR COMPRESSORS +FULL LOAD AMPERE OF OTHER MOTORS**

$$=30*2.25+30+1.5+4.5= 103A=125A$$

**(2) CABLE 440.33 ==125% X FULL LOAD AMPERE OF LARGEST MOTOR COMPRESSOR+ FULL LOAD AMPERE OF OTHER MOTOR COMPRESSORS ,MOTORS**  

$$= 30*1.25+30+1.5+4.5 = 73 A= 16 MM2$$

**(3)DISCONNECTING SWITCH= 440.12**  
**(B)(2) = all loads x 1.15**

$$=30*1.15+30+1.5+4.5=70.5 A = 90A$$

**(4) CABLE 440.33 ==125% X FULL LOAD AMPERE OF MOTOR**  

$$= 4.5*1.25 = 5.6A= 4 MM2$$

Circuit breaker size

125

AT

Cable size

16

mm<sup>2</sup>

No. of parallel cables /ph

1

C.B selection current(Amp)

103.0

Total catalogue Ampacity

250

AF

Adjusted Ampacity

88

Amp

88

Amp

EXA-MC3

